IS 5553-8 (1990): Reactors, Part 8: Smoothing reactors [ETD 16: Transformers]

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IS 5553 (Part 8) : 1990
(Reaffirmed 2004)

भारतीय मानक

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भाग 8 स्मूथिंग रिक्ऐटर

(पहला पुनरीक्षण)

Indian Standard

REACTORS — SPECIFICATION

PART 8 SMOOTHING REACTORS

(First Revision)

UDC 621·316·935

BUREAU OF INDIAN STANDARDS
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Price Group 3

FOREWORD

This Indian Standard (First Revision) was adopted by the Bureau of Indian Standards on 28 January 1990, after the draft finalized by the Transformers Sectional Committee had been approved by the Electrotechnical Division Council.

This standard was first published in 1970. This revision has been undertaken with a view to bringing it in line with IEC Pub 289 (1988) 'Reactors'.

In this revision the requirements for reactors have been covered in eight parts as follows:

Part 1 General

Part 2 Shunt reactors

Part 3 Current limiting and neutral earthing reactors

Part 4 Damping reactors

Part 5 Tuning reactors

Part 6 Earthing transformers (Neutral couplers)

Part 7 Arc suppression reactors

Part 8 Smoothing reactors

This standard (Part 8) has been based on IEC Publication 289 (1988) 'Reactors, Section 8 Smoothing reactors' issued by the International Electrotechnical Commission.

This part shall be read in conjunction with Part 1 of this standard. A list of referred standards is also given in Part 1 of this standard.

Indian Standard

REACTORS — SPECIFICATION

PART 8 SMOOTHING REACTORS

(First Revision)

1 SCOPE

1.1 This standard (Part 8) applies to smoothing reactors for dc systems. Two main application fields for smoothing reactors are defined as follows:

a) The dc has large superimposed harmonic components. This situation occurs in dc systems for industrial applications. Since the system voltages are not higher than 10 kV, the smoothing reactors are usually constructed for indoor installations;

b) The dc has smaller superimposed harmonic components. This situation occurs in HVDC transmission systems. The dc systems voltages in use or planned are 50 kV or higher. The smoothing reactors are usually constructed for outdoor installation.

Smoothing reactors are intended to provide a high impedance to the flow of harmonic currents and reduce the current rise on failure in dc systems.

1.1.1 *Design*

Smoothing reactors may be of dry type with air or water cooling or of oil immersed type. They may be constructed with or without gapped iron core or magnetic shield. They may have a linear or a non-linear magnetic characteristic.

2 TERMINOLOGY

2.0 For the purpose of this standard the following definitions shall apply.

2.1 Rated dc Current

The arithmetic mean value of the current which the apparatus is designed to carry continuously.

2.2 Rated dc Voltage

The dc voltage of the system to which reactor is to be connected.

2.3 Rated Short-Time Current

The peak value of the short-time current which the apparatus is designed to withstand.

2.4 Incremental Inductance

The incremental inductance for a specified amplitude of the principal harmonics refers to a specific direct current value.

2.5 Rated Inductance

The incremental rated inductance at rated direct current.

2.6 Winding dc Resistance

The dc resistance of the winding, measured by a direct current method related to the specified reference temperature.

2.7 Harmonic Resistance

(Under Consideration)

2.8 Harmonic Currents

The rms values of the currents at their respective harmonic frequencies.

3 RATINGS

3.1 The rated direct current and the spectrum of the harmonic currents are to be specified by the purchaser.

4 INSULATION LEVEL

4.1 Insulation Level of the Winding to Earth

This level shall correspond to the insulation level of the associated dc system.

NOTE — Additional requirements regarding creepage distance of bushings shall be subject to agreement between the manufacturer and the purchaser.

For application **1.1(b)** the insulation level comprises:

a) dc — withstand voltage,

b) lightning impulse withstand voltage (if applicable), and

c) switching impulse withstand voltage (if applicable).

4.2 Insulation Requirements Across the Winding

The insulation requirement across the winding are subject to agreement between the manufacturer and the purchaser.

5 TEMPERATURE RISE

5.1 The temperature-rise limits given in **3** of IS 2026 (Part 2) : 1977 shall apply.

6 RATING PLATES

6.1 Each reactor shall be provided with a rating plate of weather-proof material, fitted in a visible position, showing the appropriate items indicated below. The entries on the plate shall be indelibly marked (for example, by etching, engraving or stamping).

6.2 Information to be Given in All Cases

a) Kind of smoothing reactor;

b) IS Number;

c) Manufacturer's name;

d) Manufacturer's serial number;

e) Year of manufacture;

f) Highest dc system voltage;

g) Rated withstand voltages;

h) Inductance (measured value) at rated dc current, and/or for other specified current value;

j) Rated dc current;

k) Type of cooling;

m) Total mass;

n) Mass of insulating oil; and

p) Mass of core and winding assembly.

6.3 Additional Information to be Given in Certain Cases

a) Temperature class on insulation (for dry-type reactor);

b) Temperature rise (if not a normal value);

c) Details regarding water cooling (for water cooled reactors);

d) Transportation mass (for reactors exceeding 5 total mass);

e) Untanking mass (for reactors exceeding 5 t total mass); and

f) Insulating liquid, if not mineral oil.

7 TESTS

7.0 General requirements for type, routine and special tests, *see* **16.1** of IS 2026 (Part 1) : 1977.

NOTE — The tests tabulated in the following clauses shall be appropriately chosen depending on the application field of the smoothing reactor as defined in **1.1(a)** and **1.1(b)**.

7.1 Type Tests

The following shall constitute type test.

7.1.1 For reactors for the application field of **1.1(a)**:

a) Measurement of winding dc resistance [*see* **16.2** of IS 2026 (Part 1) : 1977];

b) Measurement of insulation resistance [*see* **16.6** of IS 2026 (Part 1) : 1977];

c) Measurement of inductance (*see* **7.4**); and

d) Separate-source voltage-withstand test with ac and dc voltages where applicable (*see* **7.5**).

7.1.2 For reactors for the application field of **1.1(b)**:

a) Measrement of winding dc resistance, [*see* **16.2** of IS 2026 (Part 1) : 1977];

b) Measurement of insulation resistance [*see* **16.6** of IS 2026 (Part 1) : 1977];

c) Measurement of inductance (*see* **7.4**);

d) dc voltage withstand test (*see* **7.5.2**);

e) Lightning impulse test [*see* **12** of IS 2026 (Part 3) : 1981]; and

f) Switching impulse test (*see* **7.7**).

7.1.3 *Temperature Rise Test* (*see* **7.8**)

7.2 Routine Tests

The following shall constitute routine tests.

7.2.1 For reactors for the application field of **1.1(a)**:

a) Measurement of winding dc resistance [*see* **16.2** of IS 2026 (Part 1) : 1977];

b) Measurement of insulation resistance [*see* **16.6** of IS 2026 (Part 1) : 1977];

c) Measurement of inductance (*see* **7.4**); and

d) Separate-source voltage-withstand test with ac and dc voltages where applicable (*see* **7.5**).

7.2.2 For reactors for the application field of **1.1(b)**:

a) Measurement of winding dc resistance [*see* **16.2** of IS 2026 (Part 1) : 1977];
b) Measurement of insulation resistance [*see* **16.6** of IS 2026 (Part 1) : 1977];
c) Measurement of inductance (*see* **7.4**);
d) dc voltage withstand test (*see* **7.5**);
e) Ligtning impulse test [*see* **12** of IS 2026 (Part 3) : 1981]; and
f) Switching impulse test (*see* **7.7**).

7.3 Special Test

The following shall constitute special tests:

a) Short-time current withstand test (*see* **7.9**);
b) Measurement of acoustic sound level (*see* **7.11**);
c) Measurement of vibration [*see* **6.14** of IS 5553 (Part 2) : 1990];
d) Measurement of high-frequency impedance (*see* **7.12**); and
e) Loss measurement (*see* **7.8**).

7.4 Measurement of Inductance

The inductance shall be measured at principal harmonic frequency. Smoothing reactors which have neither magnetic core nor magnetic shield may be measured at any value of current and frequency. Smoothing reactors with magnetic core or shield shall be measured at specified harmonic current superposed on rated dc current (rated inductance value) and at zero dc current (no-load inductance value). A measuring circuit as shown in Fig. 1 and 2 can be used.

Other methods can be used subject to agreement between purchaser and manufacturer.

NOTE — In some cases the measurement of total magnetic characteristic for reactors with magnetic core or shields is required. In this case **6.12** of IS 5553 (Part 2): 1990 applies.

7.5 Separate-Source Voltage Withstand Test

7.5.1 *Smoothing Reactors for the Application Filed of* **1.1(a)**

The test shall be generally carried out in accordance with **10** of IS 2026 (Part 3) : 1981.

7.5.2 *Smoothing Reactors for the Application Field of* **1.1(b)**

The following dc test (separate source) shall be performed on smoothing reactors which are normally located on the dc high voltage side. These tests, however, are not applicable for smoothing reactors at earth potential (neutral side). The test conditions for these reactors have to be agreed upon between the purchaser and the manufacturer:

a) *Oil-immersed reactors*

i) Dc voltage withstand test:

Test voltage (positive polarity) U_d = highest continuous dc operating voltage	$1{\cdot}5U_d$
Test duration	60 minutes
Interval for partial discharge (PD) measurement	The last 10 minutes
Maximum allowable number of PD pulses	10 pulses exceeding 2 000 pc

ii) Polarity reversal test:

Test voltage amplitude	$K \times U_d$
Reversal sequence and polarity	2 h (negative) — 2 minutes reversal time — 30 minutes (positive)

NOTES

1 The reconnecting time of 2 minutes for the dc test source often cannot be achieved in the test plant. It is subject to agreement between purchaser and manufacturer to stipulate longer than 2 minutes reversal time or to choose the alternative test to the polarity reversal test.

2 The factor k represents a safety margin and is usually 1·1. It is subject to agreement between the purchaser and the manufacturer to stipulate k values higher than 1·1.

iii) Short time dc voltage test

(This test is an alternative to the polarity reversal test)

Test amplitude (negative polarity)	$2U_d$
Test duration	2 minutes

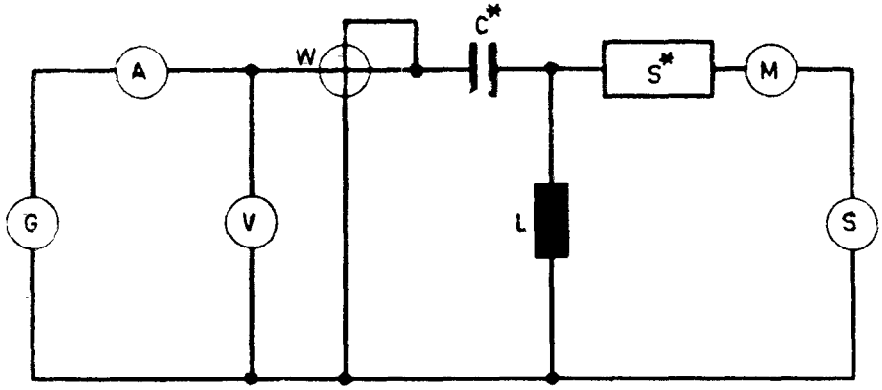
b) *Dry air-cored reactors*

Dry air-cored reactors are usually mounted on support insulators. As the insulators do not show any harmful dielectric hystersis, these reactors can be tested according to the above test given in **7.5.2**(a) (iii) only. This test shall be performed dry.

dc voltage withstand test

Test amplitude (winding-earth)	$-2U_d$ (positive polarity)
Test duration	— 2 minutes

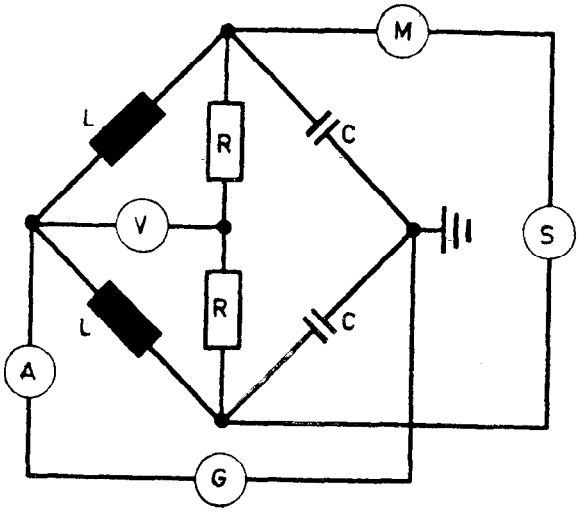
NOTE — It is subject to agreement between the purchaser and the manufacturer to perform this test as a type test only.



*At harmonic frequency the reactance shall be low for C and high for B compared with that of the smoothing reactor under test.

A = amperemeter for measurement of harmonic current
B = blocking filter to avoid ac current leakage
C = blocking capacitor to avoid dc current leakage
G = ac supply at harmonic frequency
L = smoothing reactor
M = measuring device for dc current
R = auxiliary resistor for measurement of harmonic voltage
S = dc supply
V = voltmeter for measurement of harmonic voltage
W = wattmeter for measurement of harmonic loss

FIG. 1 MEASURING CIRCUIT FOR DETERMINING INDUCTANCE AND LOSS AT HARMONIC FREQUENCY FOR SMOOTHING REACTORS HAVING IRON CORES OR SHIELDS



A = amperemeter for measurement of harmonic current
B = blocking filter to avoid ac current leakage
C = blocking capacitor to avoid dc current leakage
G = ac supply at harmonic frequency
L = smoothing reactor
M = measuring device for dc current
R = auxiliary resistor for measurement of harmonic voltage
S = dc supply
V = voltmeter for measurement of harmonic voltage
W = wattmeter for measurement of harmonic loss

FIG. 2 MEASURING CIRCUIT FOR DETERMINING INCREMENTAL INDUCTANCE OF TWO IDENTICAL LARGE SMOOTHING REACTORS

7.6 Lightning Impulse Test

This test shall be generally carried out in accordance with **12** of IS 2026 (Part 3) : 1981. The test voltage shall be applied on each terminal in succession with the opposite terminal earthed.

NOTE — If insulation requirement across the winding differ from those to earth the impulse test procedure shall be agreed upon.

7.7 Switching Impulse Test

This test shall be generally carried out in accordance with **14** of IS 2026 (Part 3) : 1981, with following exceptions:

The test shall be performed between two terminals connected together and the earth. The voltage impulse shall be of negative polarity.

NOTE — If dry-type reactors are used, tests shall be of positive and negative polarity. If such reactors are outdoor, wet tests are subject to agreement between the purchaser and the manufacturer.

7.8 Temperature-rise Test and Loss Measurement

The test shall be generally carried out in accordance with IS 2026 (Part 2) : 1977. The rated test current I_T flowing in the reactor shall be determined from the following relation:

$$R.I^2_T = R.I^2_{dN} + \Sigma P_R$$

where

I_{dN} = dc current,

ΣP_H = sum of calculated harmonic losses,

I_T = rated test current, and

R = winding dc resistance.

The loss measurement shall be determined as the product of dc resistance and the square of the rated dc test current in the winding.

7.8.1 *Dry-Type Reactors*

The test should be carried out at a value of test current I_t as near as possible to the rated test current. I_N and equal to at least 90 percent of this value and the run continued until the temperature-rise increment of the winding measured by resistance method shall not exceed 2°C in one hour.

The temperature-rise of the winding above the temperature of the cooling air for rated test current $\triangle\theta_N$, is calculated from the formula:

$$\triangle\theta_N = \triangle\theta_t \left[\frac{I_N}{I_t}\right]^2$$

The value of q shall be taken as:

AN reactors : 1·6

AF reactors : 1·8

The temperature θ_t of the winding shall be calculated from the measured resistance according to **4.3** of IS 2026 (Part 2) : 1977.

7.8.2 *Oil Immersed Type Reactors*

The determination of the top oil temperature-rise and of winding temperaturer-rises shall be made in accordance with **4** of IS 2026 (Part 2) : 1977.

7.9 Short-time Current Withstand Test

The ability of the reactor to withstand the test shall be determined in accordance with **16.11** of IS 2026 (Part 1) : 1977.

7.10 Thermal Behaviour at Short-time Current

This is in accordance with **9.0** of IS 2026 (Part 1) : 1977.

7.11 Measurement of Acoustic Sound Level

The method of test and criteria for conformity shall be agreed to between the manufacturer and the purchaser.

7.12 Measurement of High-Frequency Impedance

Measuring frequency range shall be:

a)	50 Hz to 2 500 Hz 60 Hz to 3 000 Hz	Terminal-terminal, or Terminal-terminal
b)	30 kHz to 1 MHz	Terminal-terminal Terminal-earth

8 TOLERANCE

8.1 Tolerance on the incremental inductance for reactors for the applications of **1.1(a)**:

+ 20 percent

− 0 percent of the rated inductance

Tolerance on the incremental inductance for reactors for the applications of **1.1(b)**:

± 7 of the rated incremental impedance.

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